Materials Engineering Branch

TIP*

No. 069 Coefficient of Friction Measurements

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The need arises, from time to time, to determine the coefficient of friction (CoF) between a variety of material combinations under various load conditions. The literature is replete with conflicting CoF data or data that cannot be used because specifics of the system being tested are missing or inadequate. This resulted in the development of several testing methods for the direct measurement of the static coefficient of friction using samples with surfaces matching those on the flight experiments. These methods have been used for both heavy and light loads, different material combinations and different surface roughness conditions.

ASTM G 115-98, "Standard Guide for Measuring and Reporting Friction Coefficients", describes numerous techniques for measuring both the static and dynamic coefficients of friction. However, only one of these methods[1], the sled method, is useful for our purposes. This standard also discusses many of the pitfalls associated with CoF testing and makes a strong case for the use of a standard data format. This standard should be required reading for anyone contemplating CoF testing.

Specific issues of concern include:

- Specimen geometry should resemble the components of interest as closely as possible.
- Matching the normal force, velocity and type of motion.
- Surface finish and environment are important variables.
- The stiffness of the test system employed should be matched to the materials being tested

For light loads, the test setup[2] shown in Figure 1 is used. A normal load of one pound (N = 1) is placed on a sample and then pulled by a flexible cable attached to a load cell. An Instron universal tester with a moving crosshead was used to provide the motion, load cell, and an automatic chart recording of the friction force (F). As the crosshead moves downward, the cable exerts a force on the sample at right angles to the normal force causing the sample to move intermittently across the stationary surface. As the flexible cable is alternately tensioned and relaxed, a saw-toothed load curve of the test is generated. Chart and crosshead speeds are adjusted to produce a suitable curve. Many test

[1] ASTM D 1894, "Test Method for Static and Dynamic Coefficients of Friction of Plastic Film and Sheeting".

[2] The test method is described in U.S. Patent 3,977,231, "Static Coefficient Test Method and Apparatus", Haehner et al, 21 August 1976.

data points are produced quickly (the upper points on the recorded curve) from which the static coefficient of friction, μ, is determined using F=μN.

When heavy normal loads are encountered, the frictional properties can change drastically. This was found to be the case for many polymeric materials where the static coefficient decreased as load was increased. In order to produce these heavier loads, a calibrated compression spring was used as shown in Figure 2. The coiled spring is compressed between plates to create the normal load (N) between the cube-shaped sample and its adjacent surfaces. The sample is pulled from the restrained fixture while recording the breakaway loads. Because the friction force is that of two surfaces, the load value must be halved to obtain the coefficient of friction in this case.

An additional refinement for heavier loaded conditions is the incorporation of a second calibrated load cell. Figure 3 shows a schematic diagram where a 1000-pound load cell is used to measure the manually applied normal force (N). Spherical seats maintain alignment and separate electronic circuits provide the normal load readout. The Instron measures the friction force. Similarly, the friction force could be measured on samples that have been clamped together for a prolonged period of time.

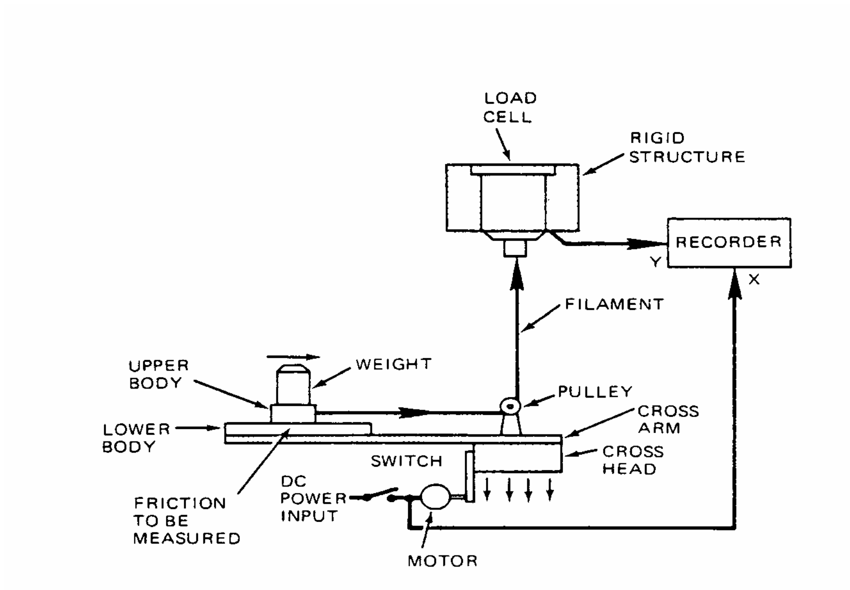

Figure 1. Apparatus for measuring static coefficient of friction.

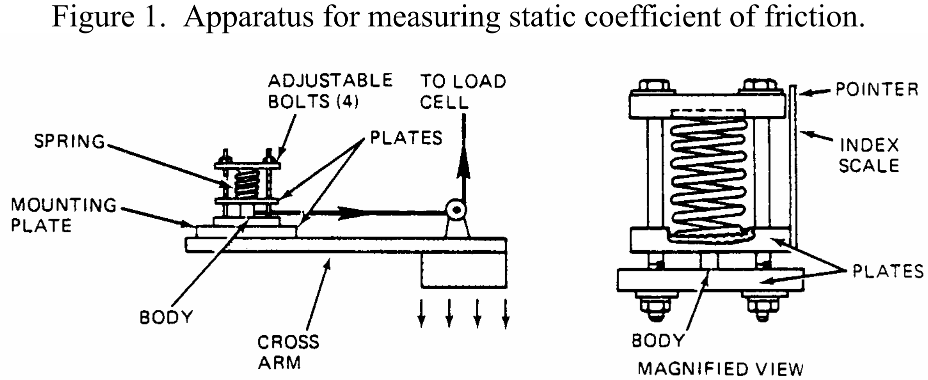

Figure 2. Use of spring to provide compressive force.

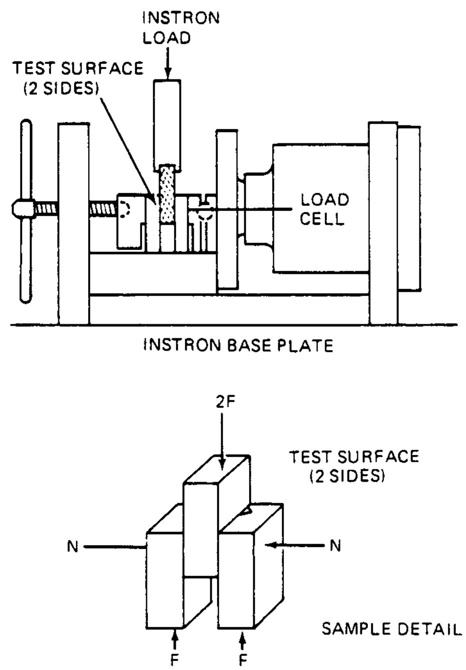

Figure 3. Use of an auxiliary load cell to measure and apply the normal force.